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Knee prosthesis

- 10 To replace the human knee joint, prosthesis types are
used whose femoral and tibial parts, depending on the
state of preservation of the ligament apparatus, are
guided relative to one another with a greater or lesser
degree of constraint. This concerns the main degrees of
15 freedom of movement of the knee, namely the flexion
movement about a transverse axis, the rotation movement
about a rotation axis running approximately parallel to
the direction of the tibia, and a translation movement
in the anteroposterior direction. The least degree of
20 mutual constrained guidance is to be found in what are
called uncoupled prostheses, which are made up simply
of a pair of femoral condyles and of a tibial sliding
surface. They are used in cases where the ligament ap-
paratus is well preserved. The other extreme is consti-
25 tuted by hinge prostheses, which are used in cases of
poorly preserved ligament apparatus and which restrict
the possible movements of the knee to the flexion move-
ment (EP-A-42 04 60, DE-OS-29 01 009). Between these
extremes there are varying degrees of partially coupled
30 systems comprising, between the femoral part and the
tibial part, an intermediate part which, by forming a
rotation bearing, takes over the guidance functions for
the rotation movement.
- 35 Among the partially coupled prostheses which permit a
rotation movement, two types are to be distinguished.
In the first type, the entire load is transmitted via
the intermediate joint component which, in relation to

the tibial part, forms a rotation bearing, and, in relation to the femoral part, forms a flexion hinge joint (DE-C-26 60 623). Since in this case the condylar sliding surfaces are intended only for a flexion movement, they can be designed congruent with the opposite surfaces. The opposite surfaces are therefore made concave with the same radius of curvature. The second type of partially coupled prostheses transmits the load not via the intermediate joint component, but directly from the condylar sliding surfaces to tibial sliding surfaces cooperating with these (EP-A-174 531). In this case, not only does a flexion movement take place between the condylar sliding surfaces and the tibial sliding surfaces, but also the rotation movement. For this reason, the tibial sliding surfaces should not be made congruent with the condylar sliding surfaces. If they are to permit a free rotation movement, the tibial sliding surfaces have to be flat. In general, however, they are allowed to slope slightly upward in front of the area in which they cooperate with the condylar surfaces when the femoral part and the tibial part have the same anteroposterior alignment (area of normal contact). This has the effect that, in the event of rotation, the condylar sliding surface displaced forward in relation to the tibial sliding surface during the rotation is lifted. This generates, under the load transmitted from the joint, a restoring torque which ensures that the prosthesis parts, as soon as is possible, return to their normal position of having the same anteroposterior alignment. During the rotation relative to the tibial part and the thereby obtained lifting of the femoral part, the rearwardly migrating condylar surface loses its contact with the tibial sliding surface. The entire load then has to be transmitted on the other side, which leads not just to increased wear, but also

to an undesired bending moment in the area of the rotation bearing. It is from this prior art, indicated in the preamble of claim 1, that the invention starts out.

5 In a known publication (DE-A-41 02 509), a partially coupled prosthesis is discussed in which both the flexion movement and also the rotation movement takes place between the femoral and tibial sliding surfaces. The femoral sliding surfaces are rounded convexly in the
10 sagittal and frontal plane. From the view of the tibial sliding surfaces, it can be concluded that they are identical to and complement the shape of the femoral sliding surfaces. This permits a rotation movement of the knee components relative to one another about the
15 flexion axis, but provides high resistance to a rotation moment about the axis parallel to the direction of the tibia. The known prosthesis is therefore not suitable for such a rotation movement. Were such a rotation to take place, however, the femoral sliding surfaces
20 would spring out of the tibial slide depressions and there would no longer be any stability of the prosthesis against further rotation. In addition, the femoral sliding surfaces would lie only on the edges of the tibial slide depressions and deform these under load.
25 The publication provides no information on how the sliding surfaces have to be configured so that they ensure both the possibility of rotation and also stability upon rotation and so that, in the event of rotation, force can be transmitted in a way that does not
30 damage the prosthesis.

Starting out from the prior art indicated in the preamble of claim 1, the object of the invention is to improve force transmission between the prosthesis components in the event of rotation about the longitudinal
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axis of the tibia. The solution lies in the feature of claim 1.

Accordingly, the tibial sliding surfaces also slope upward behind the areas of normal contact, specifically in such a way that, in the event of rotation, each of the two condylar sliding surfaces remains touching the associated tibial sliding surface; one condylar sliding surface is in contact with the upwardly sloping part of the tibial sliding surface in front of the area of normal contact, the other with the area sloping upward to the rear.

The application of this principle is advantageous in knee prostheses with a rotation axis which is fixed in relation to both prosthesis parts, in other words in which no anteroposterior movement of the prosthesis parts in relation to one another can take place. The upward slope of the tibial sliding surfaces behind the area of normal contact is then roughly the same as that in front of this area. The invention, however, can also be used in prostheses whose rotation axis is displaceable in the anteroposterior direction in relation to one of the two prosthesis parts. The condylar sliding surfaces then position themselves relative to the tibial sliding surfaces in the antero-posterior direction in such a way that the force transmission conditions on both condyles compensate each other.

The geometric relationships are particularly simple and clear when the radius of curvature of that part of the condylar sliding surfaces cooperating with the tibial sliding surface is substantially constant in the flexion plane, i.e. when the condylar sliding surfaces are configured as arcs of a circle. The invention, however,

can also be used when this is not the case. If the course of the condylar surfaces is irregular, it is nevertheless expedient to provide for relative movement of the femoral and tibial parts in the anteroposterior direction. This is not necessary when the condylar sliding surfaces are shaped in the manner of an Archimedes spiral. The profile of the condylar sliding surfaces should generally be constant.

10 The invention is explained in more detail below with reference to the drawing which depicts an advantageous illustrative embodiment and in which:

	Fig. 1	shows a side view of the prosthesis,
15	Fig. 2	shows a plan view of the tibial sliding surfaces,
	Fig. 3	shows a section through the tibial sliding surfaces, and
20	Figs 4 and 5	show two side views from opposite sides, with the femoral part rotated.

The prosthesis has a femoral part 1 and a tibial part 2 which, in a known manner, are to be anchored via pins 3, 4 respectively at the lower end of the femur and at the upper end of the tibia. The femoral part 1 has a pair of condylar sliding surfaces 5 which, at the front, come together to form a patellar sliding surface 6. The tibial part 2 forms, at the top, a support plate 7 on which the so-called tibial plateau 8 made of a material promoting sliding, for example polyethylene, is anchored, said tibial plateau 8 forming the tibial sliding surfaces 9 on which the condylar sliding surfaces 5, preferably made of polished metal, slide. The femoral part 1 and the tibial part 2 are coupled to one another by an intermediate part 10 which on the one

hand, with the femoral part 1, forms a flexion bearing with axis 11, and, on the other hand, with the tibial part, forms a rotation bearing with axis 12. Details of this construction are explained in European patent applications 1,110,261 and 1,111,551, to which reference is hereby made and whose disclosure is made part of the subject of the present application.

In the non-rotated position (Fig. 1), the femoral sliding surfaces 5 rest with their area 13, whose direction runs approximately perpendicular to the radius, on the area 14 of normal contact of the tibial sliding surfaces 9, the direction of which area 14 runs approximately perpendicular to the axis 12. Upon flexion movement, the portion lying between the area 13 and the rear end 15 of the femoral sliding surfaces can come into contact with the tibial sliding surface 9. In the example shown, this portion extends as an arc of a circle of constant radius to the flexion axis 11. The profile of the sliding surface is constant in this portion.

The area 14 of the tibial sliding surface 9 has the same profile (in frontal section) as that portion 13-15 of the associated femoral sliding surface cooperating with it. This means that, in the non-rotated state, theoretical linear contact exists. In practical terms, surface contact is obtained as a result of the compliance of the material of the tibial sliding surfaces 9.

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That portion 6 of the condylar sliding surfaces and of the patellar sliding surface lying in front of the area 13 is not of importance as regards the transmission of the load forces to the tibial part 2 of the prosthesis.

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The tibial sliding surface 9 is weakly concave in the sagittal plane, as is shown in Fig. 3. The radius of curvature is considerably greater than the radius of the femoral sliding surface portion 13-15. This is necessary so that, in the event of rotation, the femoral sliding surfaces can move forward and backward a slight distance - substantially without impediment - starting from the area of normal contact 14. In the event of powerful rotation, the condylar sliding surfaces 5 leave the area 14 of normal contact. On one side (see Fig. 4), they move in the upwardly sloping portion 16 of the tibial sliding surfaces which lies in front of the area of normal contact 14. On the other side (Fig. 5), they move in the rear, upwardly sloping portion 17 of the tibial sliding surfaces 9.

The tibial sliding surfaces are shaped in such a way that, in the event of such rotation, the condylar sliding surfaces 5 maintain contact with the tibial sliding surface 9 on both sides, namely, on one side with the front portion 16, and, on the other side, with the rear portion 17.

If one wishes to maintain linear contact between the condylar sliding surfaces 5 and the tibial sliding surfaces 9 in these portions, then the tibial sliding surfaces 9 have to be shaped such that they have the same profile as the condylar sliding surfaces 5 in the direction of circle arcs 20 about the rotation axis 12 in a sectional plane containing this rotation axis. This can readily be achieved with the aid of a tool which has the profile of the condylar sliding surfaces and is rotated about the axis 12. However, this is relatively complicated. It is simpler to mill the tibial sliding surfaces 9 by means of tools that are moved in the an-

teroposterior direction 20. In this case, when rotation takes place, the ideal linear contact between the condylar sliding surfaces 5 and the tibial sliding surfaces 9 is dispensed with to a greater extent the farther the point of the respective contact is removed from the area 14 of normal contact. This is not a problem, however, because such strong rotation occurs relatively rarely and the periods of sustained load transmission to the area 14 of normal contact are limited.

10 In the event of such strong rotation, it is crucial that not just one of the two condylar sliding surfaces cooperates with the tibial sliding surface, but both.